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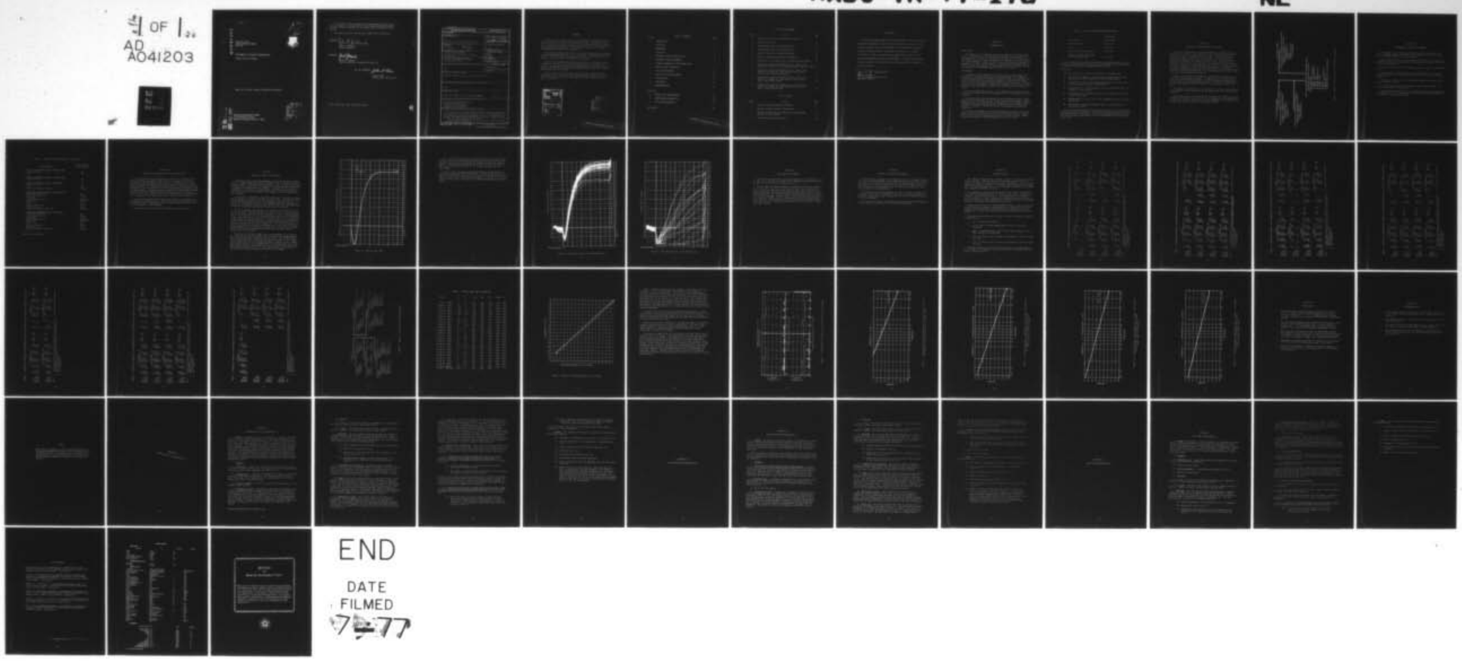

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Final Technical Report
May 1977

SOLDERABILITY TESTING OF MICROCIRCUITS

General Electric Company

ROME AIR DEVELOPMENT CENTER
Air Force Systems Command
Griffiss Air Force Base, New York 13441

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Solderability tests were performed on Fe-Ni-Co and Fe-Ni microelectronic lead base materials with surface preparations as required by MIL-M-38510C. Test samples were used from four different sources. The solderability tests included MIL-STD-883A, Meniscograph and Hot Iron methods. Sample data from the three test methods showed good correlation.

Microelectronic lead aging studies showed that the current steam aging environment should be retained.

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SUMMARY

Microelectronic lead solderability test acceptance criteria are subjective and are based on surface area wetted during test. The inspection for surface wetting is dependent on the need for continual training or retraining. Because industry has encountered problems with objective measurement of lead solderability acceptance or deterioration, a study of the current MIL-STD-883A Method 2003.1 was undertaken.

Laboratory experiments were used to study the current method as compared to the Meniscograph method and the hot iron method. The Meniscograph method supplies objective criteria for acceptance and the hot iron method is designed as an 'on the spot' solderability test procedure.

Results of the experimental work show that there is correlation between the current criteria and the criteria established for the other two test methods. The current steam aging environment should be continued. The experiments did not show a significant difference between lead base materials when prepared per MIL-M-38510C.

Further study is required to define an accelerated aging environment equivalent to industrial conditions. Additional work should be done to define acceptance criteria for solderability acceptance when other than 'R' type flux is used.

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EVALUATION

This effort supports RADC TPO R-5-B, Reliability. The test procedures documented in Appendix B and C of this report have been submitted to the Preparing Activity (PA) for Method 2003.1 of MIL-STD-883A for proposed inclusion in that document as alternative test methods to the 883A test method. Action on including these methods will be taken at the 9-12 May coordination meeting on MIL-STD-883A. The PA was also notified that the existing test method 2003.1 was evaluated and is acceptable as presently written.

John E. McCormick

JOHN E. McCORMICK
Solid State Applications Section
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SECTION I

INTRODUCTION

OBJECTIVES

The purpose of this study was to review and update the existing Method 2003.1, Solderability, of MIL-STD-883A, Test Methods and Procedures for Microelectronics, as well as to investigate the Meniscus Force Solderability Test Method and the Hot Iron Solderability Test Method, for possible inclusion in MIL-STD-883A. (Copies of these three test methods are included in Appendices A, B and C of this report.) Investigation of steam and other accelerated aging environments, and investigation of lead finishes, sizes and base materials of MIL-M-38510C were also part of the study.

BACKGROUND

A subjective visual inspection is a part of the current procedure for solderability testing of microelectronic package leads. This inspection includes observations for "at least 95 percent coverage by a continuous new solder coating" and "verification that pinholes or voids are not concentrated in one area and do not exceed 5 percent of the total area." In cases of dispute, the percentage of coverage with pinholes or voids is to be determined by actual measurement of these areas, as compared to the total area tested.

The visual inspections required in this method have been known to cause a need for continual training or retraining cycles at both supplier and user facilities.

The solderability tests are generally applied immediately after surface preparation at a producing facility or upon receipt after purchase. Solderability testing is usually followed by storage periods of different lengths. Environments during storage may or may not deteriorate the surface to be soldered. The amount of deterioration may vary depending on the surface preparation.

The surface preparations covered in MIL-M-38510C include hot solder dip (HSD) over nickel, bright acid tin (BAT) or gold; bright acid tin; bright acid tin over nickel or copper; gold; gold over nickel or copper. Surface preparation thicknesses from MIL-M-38510C are listed in Table 1.

TABLE 1. SPECIFIED SURFACE PREPARATION THICKNESS

	Microinches
Hot Solder Dip	200 (minimum)
Bright Acid Tin	100 to 400
Gold	50 to 225
Nickel under Hot Solder Dip	100 to 200
Nickel or Copper under Bright Acid Tin or under Gold	10 to 100

These variations in surface protection for solderability have, at times, resulted in dissatisfaction with the current solderability test method along with the accelerated aging environment included therein.

STUDY PLAN

The study described in this report involved the following tasks:

- Acquisition of samples of microelectronic packages with the base material and surface preparation covered in MIL-M-38510C.
- Preparation of some of the base material acquired, to each of the surface treatments covered in MIL-M-38510C.
- Determination of the applicability of the current Method 2003.1 as compared to other methods.
- Determination of the "Meniscus Force" test compatibility with the current Method 2003.1.
- Determination of the "hot iron" test compatibility with the current Method 2003.1.
- Determination of aging environment effects on solderability of microcircuit leads.

The study involved setting up plating baths for each of the surface preparations included in MIL-M-38510C, in addition to obtaining devices with vendor standard surface preparation. This was accomplished for both lead base materials included in MIL-M-38510C, an iron-nickel-cobalt alloy and an iron-nickel alloy.

SECTION 2

MATERIALS ACQUIRED FOR THE STUDY

All devices acquired were of the MIL-M-38510C case outline F-2 type (14-lead, 1/4" x 3/8"). Also acquired was sheet material from which lead frames are stamped or chemically milled. Figure 1 shows the variety of materials acquired and prepared in the laboratory at General Electric. Fe-Ni-Co base packages were acquired from Vendor No. 1, with lead surface preparation standard in the vendor's facility. These were plated with bright acid tin or gold. The cross-section and polish technique at GE did not reveal a presence of undercoating on these devices. Packages which had no surface preparation on the leads were also obtained from Vendor No. 1. Packages of Fe-Ni-Co base material which had bright acid tin surface preparation are acquired from Vendor No. 2. No undercoating was observed on these leads when cross-sectioned and polished.

Packages were acquired from Vendor No. 3 with Fe-Ni base material, prepared with their standard treatments -- bright acid tin, gold and bright acid tin followed by hot solder dip. No undercoatings were observed when the leads were cross-sectioned and polished. In addition, packages with no surface preparation on the Fe-Ni base material were acquired from Vendor No. 3.

The packages from Vendor No. 1 and Vendor No. 3 with no surface preparation underwent surface preparation in the laboratory at GE, as described in Section 3.

All specimen types, those prepared and treated by the vendors, and those subsequently treated in the laboratory at GE underwent initial solderability testing, prior to being exposed to an aging environment, for comparison with results after aging, as discussed in Sections 7 and 8.

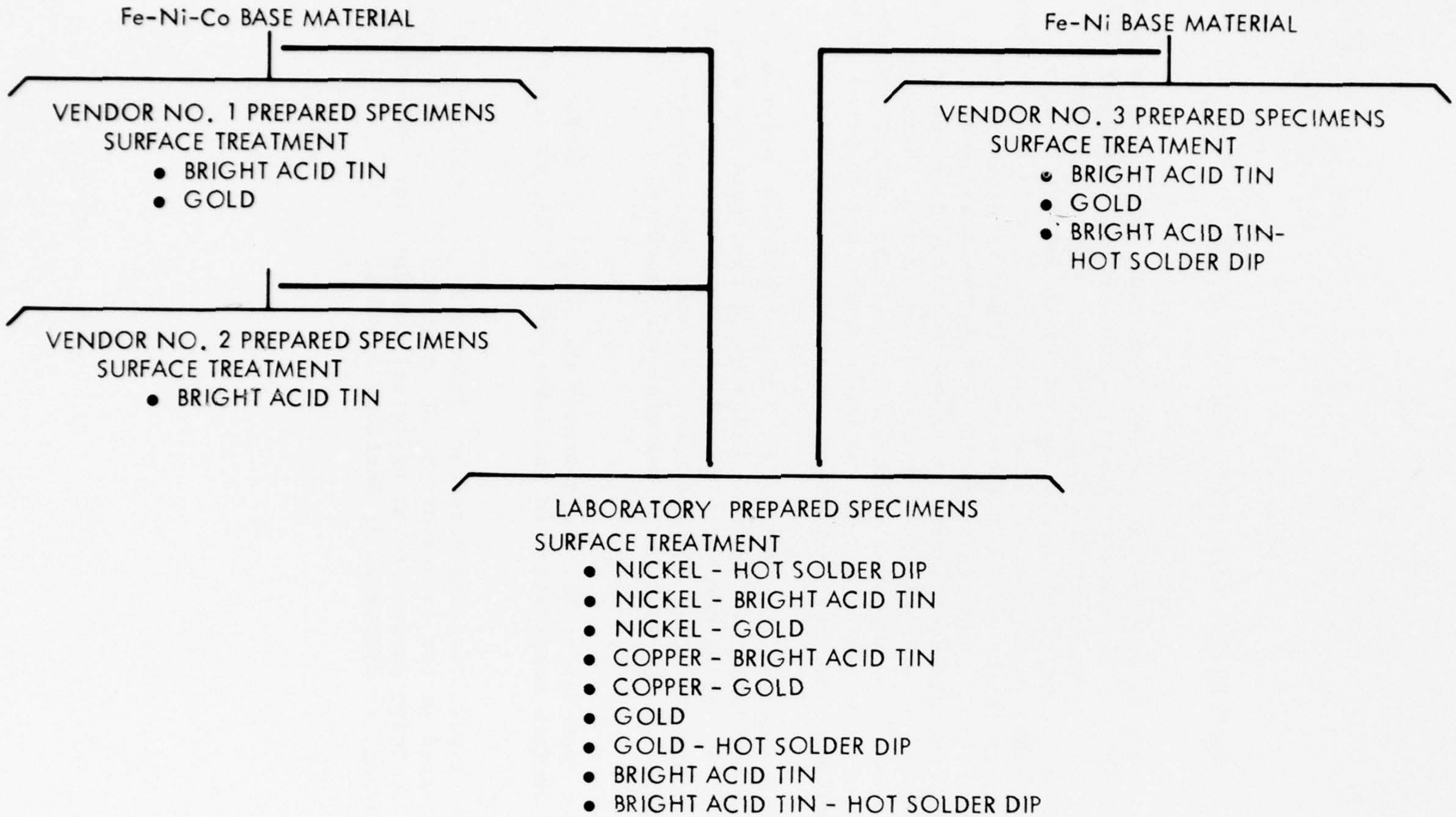

Figure 1. Matrix of Microcircuit Test Specimen Preparation

SECTION 3

LABORATORY SURFACE TREATMENT

The packages with no surface preparation, acquired from Vendors No. 1 and 3, underwent surface preparation in the laboratory at GE to the entire list of allowable surfaces as shown in Figure 1.

Table 2 shows the lead surface preparation thicknesses as measured after cross-sectioning and polishing using light microscope techniques. All values shown are in microinches.

The gold used was 99.9% purity whether acquired or applied in the laboratory.

The lead frames in packages acquired from Vendor No. 1 were formed by chemical milling; those from Vendors No. 2 and 3 were formed by a stamping operation.

Base material from each of the vendors was analyzed to ascertain that it was of the alloy ordered.

The nickel deposition was performed by an electroless procedure; all other coatings were electrodeposited.

As noted previously in Section 2, the packages with surfaces prepared in the laboratory at GE were subjected to initial solderability testing, prior to exposure to the aging environment.

TABLE 2. MEASURED SURFACE PREPARATION THICKNESSES

Surface Material	Surface Thickness (microinches)
Vendor No. 1 Prepared Surface - Fe-Ni-Co Base	
Bright Acid Tin	200
Gold	50
Vendor No. 2 Prepared Surface - Fe-Ni-Co Base	
Bright Acid Tin	150
Vendor No. 3 Prepared Surface - Fe-Ni Base	
Bright Acid Tin	200
Gold	50
Bright Acid Tin/Hot Solder Dip	200/200
GE Laboratory Prepared Surface - Fe-Ni-Co Base	
Nickel/Hot Solder Dip	20/*
Nickel/Bright Acid Tin	10/100
Nickel/Gold	10/50
Copper/Bright Acid Tin	Flash/200
Copper/Gold	30/50
Gold	50
Gold/Hot Solder Dip	50/200
Bright Acid Tin	130
Bright Acid Tin/Hot Solder Dip	130/200
GE Laboratory Prepared Surface - Fe-Ni Base	
Nickel/Hot Solder Dip	20/*
Nickel/Bright Acid Tin	10/100
Nickel/Gold	10/50
Copper/Bright Acid Tin	Flash/200
Copper/Gold	30/50
Gold	50
Gold/Hot Solder Dip	50/200
Bright Acid Tin	130
Bright Acid Tin/Hot Solder Dip	130/200

*Would not accept solder.

SECTION 4

CURRENT SOLDERABILITY TEST METHOD 2003.1

The current Method 2003.1 (Appendix A) provides the necessary information on surface solderability but it does not provide the necessary information on wetting speed or wetting forces. Assuming that a surface meets the minimum rquirements of the current method after the five second immersion period, it is intuitively assumed that the surface should be used immediately in its end application since any degradation would make its application unusable. Present day use of automated or semi-automated assembly techniques requires information about the wetting speed and the wetting force on a part lead. These characteristics show that the surface wets within the application time limits, and that the wetting force is positive.

For this investigation devices which were prepared in accordance with MIL-M-38510C were subjected to the test conditions of MIL-STD-883A by use of the "Meniscus Force" test method. The test surfaces were inspected to the visual requirements of MIL-STD-883A.

The Meniscus Force test method is discussed in the next section.

SECTION 5

MENISCUS FORCE TEST METHOD

The Meniscus Force test method (Appendix B) used in this study utilized the G.E.C. Meniscograph produced by the General Electric Company Limited of Wembly, England. The Meniscograph incorporates a pair of cantilever springs to support the test specimen. An armature of a linear variable differential transformer is mounted between the springs. The output of the armature/transformer is a positive or negative direct current signal proportional to the forces acting on the test piece. This signal is fed to an amplifier/chart recorder.

In operation, a temperature controlled solder bath is raised to a preset immersion depth of the test piece into the solder bath. The speed of solder bath movement is also preset. At the conclusion of the selected test period, the solder bath is lowered. A simulated recording of wetting force versus time is shown in Figure 2. Those areas of the force curve which are of concern in determining solderability are noted in the figure.

The first portion, negative trace, is caused by the rejection of solder by the test piece. The time period of the negative trace is determined by the flux activation and time for the test piece to come to soldering temperature. The test leads used in this study should come to solder temperature in less than 0.0002 second. The initial wetting speed of the test specimen is measured by the time elapsed to T_1. At T_1 the meniscus is approximately at 90° to the test specimen and at zero balance on the wetting force, i.e., armature/transformer direct current signal "0". The final wetting speed of the test specimen is measured by the elapsed time to the point T_2DC, where maximum wetting force is achieved. The T_2DC and 5 DC points are a measure of the stability of the maximum wetting force from the time initially achieved to test termination.

The end use of the device under test is most dependent on the time to T_1. This time must not be delayed to the point where the maximum wetting force cannot be achieved during the time to solder. Most assembly operations require that time to solder be limited to a maximum of six seconds; this is dependent on the heat sinking provided to protect devices. Sample devices which exhibit a short wetting time to T_1 indicate that the lot sampled has the ability to be assembled at a more rapid rate than those lots which exhibit a longer time to T_1. This wetting speed can be reduced by subsequent handling and forming operations prior to assembly.

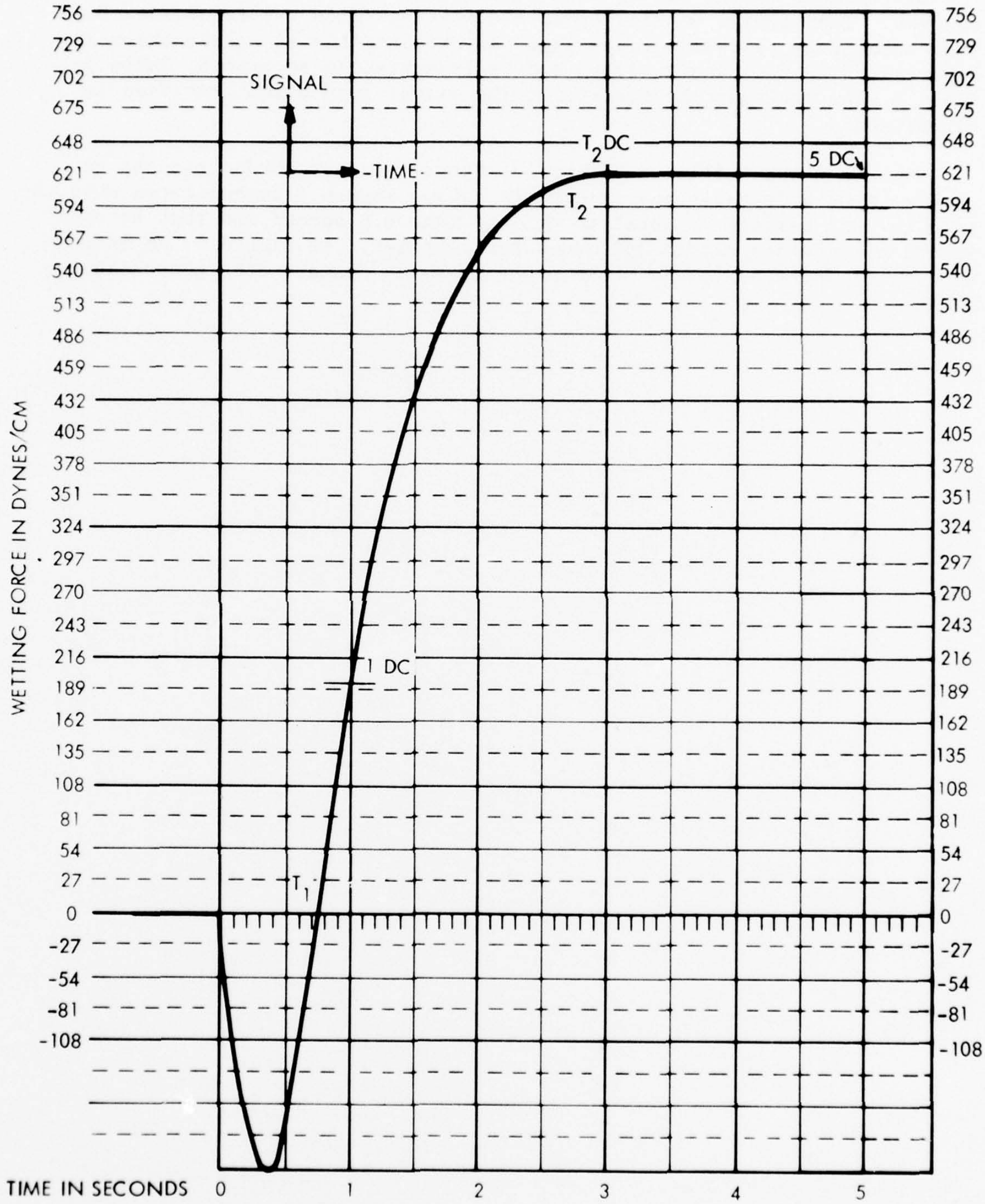

Figure 2. Meniscus Force Curve

All devices tested during this study were tested by use of the Meniscograph. Each device wetting speed and wetting force was recorded. Data from each group of device recordings was obtained via the scale shown in Figure 2. The data was analyzed and is presented in Section 8, Table 3. Table 3 also includes the results of the visual inspection specified in MIL-STD-883A.

Figures 3 and 4 illustrate typical Meniscograph recorded results on samples from acceptable and rejectable lots. Figure 3 demonstrates that the time to zero balance is equal to or less than 0.4 second and that at one second all devices exceed 350 dynes per centimer. In Figure 4, an extreme variety of force curves is shown, none of which demonstrates good solderability.

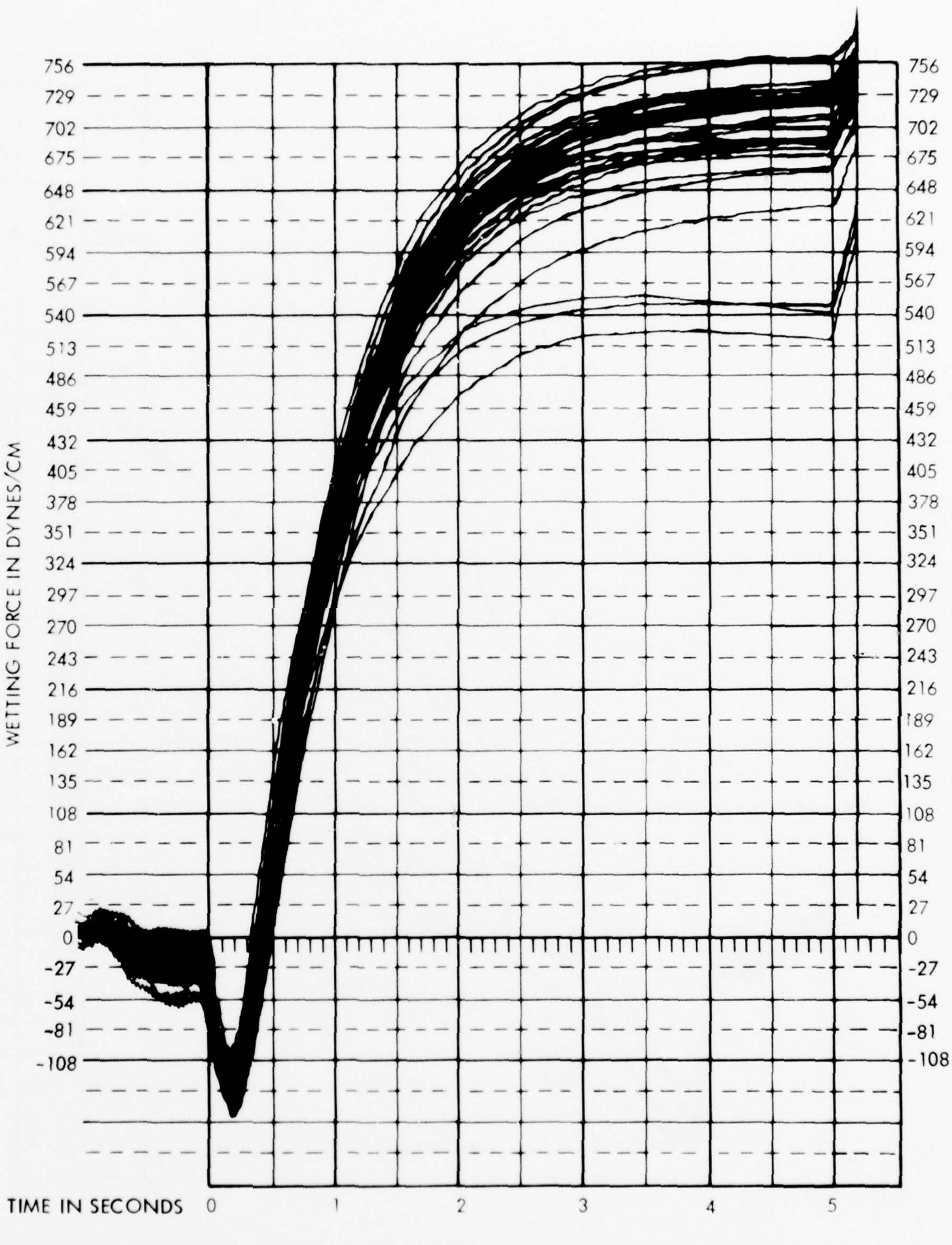

Figure 3. Meniscograph Curves (Good Solderability)

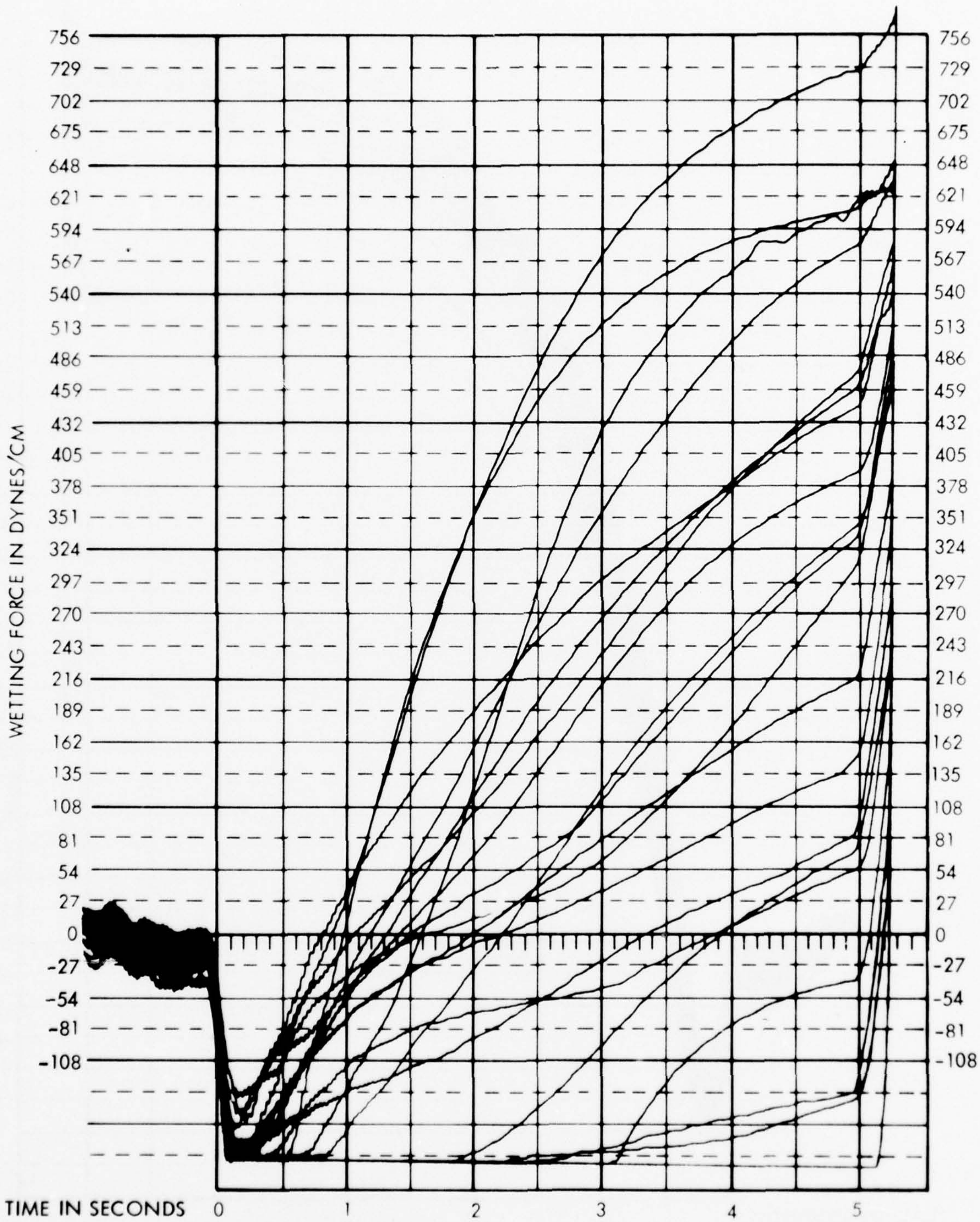

Figure 4. Meniscograph Curves (Poor Solderability)

SECTION 6

HOT IRON TEST METHOD

The hot iron solderability test method (Appendix C) is designed as an on the spot test. The test is intended to be used when appraising material at any spot in the acquisition or application cycle.

The hot iron test procedure employs a temperature controlled soldering iron set at 343°C. The test is intended to be used only on tinned part leads. After flux application, the soldering iron tip is moved along the edges and surfaces of a lead while observing solder flow with 10 to 15 X stereo Macroscope. The time of soldering iron application should be limited to six seconds maximum. A smooth flow of solder indicates good solderability; sluggish or puddled solder or dewetting indicate poor solderability. Parts from each of the groups of devices tested in this study were subjected to the hot iron test. The results are listed in Section 8, Table 3 along with other results.

SECTION 7

EFFECTS OF AGING ENVIRONMENT

. Study effort was expended on reviewing the effects of the aging environment included in MIL-STD-883A. Some additional effort was applied to the development of other aging environments. The environments used in this study were steam for one hour; 95 percent humidity at 95° Centigrade; and a 20 minute exposure in the atmosphere above a 6% solution of ammonium polysulfide and water at room temperature.

The ammonium polysulfide atmosphere was used to compare solderability results with those results obtained from aging in a stock room atmosphere at the plant. Other devices were subjected to the steam, 95% RH/95°C, and the stock room atmosphere.

All devices were tested on the Meniscograph adjusted to MIL-STD-883A conditions, and then inspected to the criteria of MIL-STD-883A.

SECTION 8

STUDY RESULTS

The summary of study results is listed in Table 3. There were 49 groups of devices tested. Both sets of device leads were tested in all test groups. The matrix of base material, surface preparation on leads and test environment is shown in Figure 5. All devices were subjected to Test Method 2003.1 on the Meniscograph, and visually inspected to Method 2003.1; samples were subjected to the hot iron test.

For comparison, Table 4 shows the results of the initial solderability tests, which were performed prior to subjecting specimens to the aging environment. All groups, except No. 1, 10, 19 and 28 met the acceptance criteria initially. (These criteria are discussed later in this section.) These four groups were those prepared with electroless nickel and an attempt was made to hot solder dip them using "R" type flux.

Devices tested were all of one MIL-M-38510C outline. Figure 6 shows the relationship of test surface circumference (at the meniscus) to dynes per centimeter force, measured by the Meniscograph on clean Fe-Ni-Co using Tinners flux. The data was acquired at the five second point on the force curves.

The points on the force curve in Figure 2, which are usable to evaluate solderability are:

1. T_1 - or time to zero balance.

2. T_2 - or time to achieve maximum meniscus force in dynes per centimeter.

3. T_2DC - or maximum meniscus force in dynes per centimeter at the time maximum is first achieved.

4. 1 DC - or meniscus force in dynes per centimeter at the one second test time.

5. 5 DC - or meniscus force in dynes per centimeter at the five second test time.

Data was acquired from each group of device force curves and analyzed for the purpose of comparison to the visual inspection of Method 2003.1 and the hot iron test results.

TABLE 3. STATISTICAL ANALYSIS DATA COMPARED WITH MIL-STD-883A AND HOT IRON TEST RESULTS

	Group 1 Fe-Ni-Co/Ni-HSD/Nat Age							Group 19 Fe-Ni-Co/Ni-HSD/Polysulfide						
	T_1	T_2	T_2DC	1DC	5DC	883A*	H I	T_1	T_2	T_2DC	1DC	5DC	883A*	H I
Mean	>5	>5	-216	-216	-216	Fail	Fail	>5	>5	-216	-216	-216	Fail	Fail
Std Dev	-	-	-	-	-			-	-	-	-	-		
Variance	-	-	-	-	-			-	-	-	-	-		
#Pts Inc	20	20	20	20	20			20	20	20	20	20		

	Group 2 Fe-Ni-Co/Ni-BAT/Nat Age							Group 20 Fe-Ni-Co/Ni-BAT/Polysulfide						
	T_1	T_2	T_2DC	1DC	5DC	883A*	H I	T_1	T_2	T_2DC	1DC	5DC	883A*	H I
Mean	035	3 83	666 1	527	686 35	Pass	Pass	1 684	3 5	53 5	-48 41	32 5	Fail	Fail
Std Dev	.0162	.6614	99.53	50.06	71.35			.626	.707	14.798	37.1	82.3		
Variance	00025	389	8804	2381	4836			371	250	164.3	1377	6766		
#Pts Inc	20	9	9	20	20			19	2	4	22	24		

	Group 3 Fe-Ni-Co/Ni-Au/Nat Age							Group 21 Fe-Ni-Co/Ni-Au/Polysulfide						
	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.	T_1	T_2	T_2DC	1DC	5DC	883A*	H I
Mean	3	3.92	545.6	330 5	569 5	Pass	Pass	2 07	-	-	-102 7	37 96	Fail	Fail
Std Dev	.0324	.188	66.62	39.37	59.83			1.072	-	-	114.4	308.5		
Variance	001	0325	4097	1472	3681			1 034	-	-	13088	95139		
#Pts Inc	20	13	13	20	32			10	-	-	27	27		

	Group 4 Fe-Ni-Co/Cu-BAT/Nat Age							Group 22 Fe-Ni-Co/Cu-BAT/Polysulfide						
	T_1	T_2	T_2DC	1DC	5DC	883A*	H I	T_1	T_2	T_2DC	1DC	5DC	883A*	H I
Mean	4	3 59	589 2	329 3	595 4	Fail	Fail	1 58	4 1	173 6	-115 7	-8 5	Fail	Fail
Std Dev	.0324	.3678	55.66	41.06	62.87	Note 2		.78	.652	106.5	76.5	162.3		
Variance	001	1303	2983	1605	3807			548	.340	9066	5854	26349		
#Pts Inc	20	27	27	21	27			10	5	5	24	24		

Notes:
1. Fe-Ni-Co Base Specimens in Groups 47 through 49 are from Vendor No. 2. All other Fe-Ni-Co Specimens are from Vendor No. 1. All Fe-Ni Base Specimens are from Vendor No. 3.
2. Copper under plate peeled.
3. * - Visual inspection
4. BL** - Border Line

TABLE 3. STATISTICAL ANALYSIS DATA COMPARED WITH MIL-STD-883A AND HOT IRON TEST RESULTS (Continued)

	Group 5 Fe-Ni-Co/Cu-Au/Nat. Age							Group 23 Fe-Ni-Co/Cu-Au/Polysulfide						
	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.
Mean	.35	2.8	392.8	174.1	180.2	Fail	Fail	1.646	-	-	-29.5	311.3	Fail	Fail
Std Dev	.081	.523	72.14	162.5	163.7	Note 2		1.267	-	-	138.96	201.24		
Variance	.006	.26	4944	26411	26790			1.538	-	-	19310	40499		
#Pts Inc	20	20	20	33	33			24	-	-	23	24		

	Group 6 Fe-Ni-Co/Au/Nat. Age							Group 24 Fe-Ni-Co/Au/Polysulfide						
	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.
Mean	.0505	2.25	380.5	308.9	380.5	Pass	Pass	.831	3.917	608	195.6	589.2	Fail	BL**
Std Dev	.0147	.0811	40.05	31.51	40.05			.966	.204	55.08	177.28	161.32		
Variance	.0002	.0063	1554	92.08	1554			.897	.0347	2528.3	31429	24982		
#Pts Inc	20	20	32	32	32			26	6	6	26	25		

	Group 7 Fe-Ni-Co/Au-HSD/Nat. Age							Group 25 Fe-Ni-Co/Au-HSD/Polysulfide						
	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.
Mean	.295	.64	479.97	301.6	479.97	Pass	Pass	.867	3.93	604.29	118.78	569.86	Pass	Pass
Std Dev	.1075	.8963	56.115	46.93	56.115			.775	.4499	76.45	159.93	187.97		
Variance	.01097	.76315	3059.9	2136.	3058.9			.578	.173	5010	25578	35332		
#Pts Inc	20	20	35	33	35			27	7	7	27	28		

	Group 8 Fe-Ni-Co/BAT/Nat. Age							Group 26 Fe-Ni-Co/BAT/Polysulfide						
	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.
Mean	.375	3.995	676.47	381.9	676.47	Pass	Pass	.524	3.94	672.1	236.5	566.3	Fail	Pass
Std Dev	.0243	.1791	54.91	44.118	54.91			.502	.177	82.126	190.77	286.61		
Variance	.00056	.03048	2920.6	1885.5	2920.6			.2418	.027	5901.6	36393	82143		
#Pts Inc	20	20	32	32	32			25	8	8	25	27		

Notes:
1. Fe-Ni-Co Base Specimens in Groups 47 through 49 are from Vendor No. 2. All other Fe-Ni-Co Specimens are from Vendor No. 1. All Fe-Ni Base Specimens are from Vendor No. 3.
2. Copper under plate peeled.
3. * - Visual inspection
4. BL** - Border Line

TABLE 3. STATISTICAL ANALYSIS DATA COMPARED WITH MIL-STD-883A AND HOT IRON TEST RESULTS (Continued)

	Group 9 Fe-Ni-Co/BAT-HSD/Nat Age							Group 27 Fe-Ni-Co/BAT-HSD/Polysulfide						
	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.
Mean	.3575	3.995	479.7	476.7	479.7	Pass	Pass	.559	4.17	528.53	121.41	425.93	Fail	Fail
Std Dev	.0373	.1791	56.369	45.89	56.369			.159	.3086	115.66	132.40	250.86		
Variance	.0013	.0305	3084	2041.9	3084			.024	.089	12484	17531	62932		
#Pts Inc	20	20	34	33	34			22	15	15	29	28		

	Group 10 Fe-Ni/Ni-HSD/Nat. Age							Group 28 Fe-Ni/Ni-HSD/Polysulfide						
	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.
Mean	>5	>5	-216	-216	-216	Fail	Fail	>5	>5	-216	-216	-216	Fail	Fail
Std Dev	-	-	-	-	-			-	-	-	-	-		
Variance	-	-	-	-	-			-	-	-	-	-		
#Pts Inc	20	20	20	20	20			20	20	20	20	20		

	Group 11 Fe-Ni/Ni-BAT/Nat. Age							Group 29 Fe-Ni/Ni-BAT/Polysulfide						
	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.
Mean	.408	3.75	628.58	351.7	658.9	Pass	Pass	1.006	3.33	33.3	96.31	368.9	Fail	Pass
Std Dev	.0493	.399	78.93	45.39	94.33			.7611	.577	30.55	116.	256.86		
Variance	.0023	.1458	5711.2	1962.1	8474.5			.543	.222	622.2	13456	61855.		
#Pts Inc	25	12	12	21	21			16	3	3	16	16		

	Group 12 Fe-Ni/Ni-Au/Nat. Age							Group 30 Fe-Ni/Ni-Au/Polysulfide						
	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.
Mean	.292	4.17	570.	372.	652.3	Pass	Pass	1.4125	-	-	-4.3125	469.8	Fail	Pass
Std Dev	.0493	.2887	9.99	31.16	64.46			1.065	-	-	94.44	199.08		
Variance	.0023	.056	66.67	924.76	3957.8			1.0636	-	-	8918.8	37155		
#Pts Inc	25	3	3	21	21			16	-	-	16	16		

Notes:
1. Fe-Ni-Co Base Specimens in Groups 47 through 49 are from Vendor No. 2. All other Fe-Ni-Co Specimens are from Vendor No. 1. All Fe-Ni Base Specimens are from Vendor No. 3.
2. Copper under plate peeled.
3. * - Visual inspection
4. BL** - Border Line

TABLE 3. STATISTICAL ANALYSIS DATA COMPARED WITH MIL-STD-883A AND HOT IRON TEST RESULTS (Continued)

Group 13
Fe-Ni/Cu-BAT/Nat. Age

	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.
Mean	.408	3.861	561.83	288.4	569.58	Pass	Fail
Std Dev	.0493	.3346	46.63	53.56	49.99		
Variance	.0023	.1057	2053.7	2725.	2395.7		
#Pts Inc	25	18	18	20	24		

Group 31
Fe-Ni/Cu-BAT/Polysulfide

	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.
Mean	1.44	-	-	-111.19	55.38	Fail	Fail
Std Dev	.5747	-	-	110.38	231.8		
Variance	.294	-	-	12184	53727		
#Pts Inc	13	-	-	16	16		

Group 14
Fe-Ni/Cu-Au/Nat. Age

	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.
Mean	.25	2.92	482.89	351.5	483.26	Pass	Pass
Std Dev	.0144	.5593	81.45	45.36	82.99		
Variance	.0002	.2964	6284.9	1978.4	6588.3		
#Pts Inc	25	19	19	26	23		

Group 32
Fe-Ni/Cu-Au/Polysulfide

	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.
Mean	.725	4.25	727.	172.	618.4	Fail	Fail
Std Dev	.595	.354	2.83	125.65	115.83		
Variance	.3319	.0625	4.	15788	12579		
#Pts Inc	16	2	2	16	16		

Group 15
Fe-Ni/Au/Nat. Age

	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.
Mean	.228	3.654	563.1	325.5	574.1	Pass	Fail
Std Dev	.1137	.5158	94.70	95.03	125.81		
Variance	.0124	.2456	8278.9	8599.8	15167.5		
#Pts Inc	25	13	13	21	24		

Group 33
Fe-Ni/Au/Polysulfide

	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.
Mean	1.453	3.75	569.5	-13.6	372.69	Fail	Fail
Std Dev	.921	.3536	34.65	132.99	204.1374		
Variance	.792	.0625	600.25	17686	41672		
#Pts Inc	15	2	2	16	16		

Group 16
Fe-Ni/Au-HSD/Nat. Age

	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.
Mean	.30	3.17	521.07	314.76	554.35	Pass	Pass
Std Dev	.065	.523	90.198	61.21	98.63		
Variance	.004	.256	7593.	3568.	9305.		
#Pts Inc	25	15	15	21	23		

Group 34
Fe-Ni/Au-HSD/Polysulfide

	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.
Mean	1.885	-	-	-98.8	233.1	Fail	Fail
Std Dev	1.142	-	-	112.5	230.9		
Variance	1.204	-	-	12649.6	53326		
#Pts Inc	13	-	-	16	16		

Notes:
1. Fe-Ni-Co Base Specimens in Groups 47 through 49 are from Vendor No. 2. All other Fe-Ni-Co Specimens are from Vendor No. 1. All Fe-Ni Base Specimens are from Vendor No. 3.
2. Copper under plate peeled.
3. * - Visual inspection
4. BL** - Border Line

TABLE 3. STATISTICAL ANALYSIS DATA COMPARED WITH MIL-STD-883A AND HOT IRON TEST RESULTS (Continued)

	Group 17 Fe-Ni/BAT/Nat. Age							Group 35 Fe-Ni/BAT/Polysulfide						
	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.
Mean	.362	3.67	657.17	368.7	679.8	Pass	Pass	1.3	3	44.67	-121.	-88.9	Fail	Pass
Std Dev	.044	.5423	67.81	45.95	77.61			.173	0	20.4	72.7	102.1		
Variance	.00186	.278	4343.	2011.	5761			.02	0	277.56	5288	10427		
#Pts Inc	25	18	18	21	23			3	3	3	16	16		

	Group 18 Fe-Ni/BAT-HSD/Nat. Age							Group 36 Fe-Ni/BAT-HSD/Polysulfide						
	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.
Mean	.4	3.4375	631.81	393.3	628.	Pass	Pass	1.6	3.5	-	-108.	25.7	Fail	Pass
Std Dev	.0289	.4031	62.39	39.96	73.84			.396	-	-	69.27	173.5		
Variance	.0008	.1523	3649.7	1517.2	5215.5			.1343	-	-	4798.	30098		
#Pts Inc	25	16	16	20	23			7	1	-	13	13		

Notes:
1. Fe-Ni-Co Base Specimens in Groups 47 through 49 are from Vendor No. 2. All other Fe-Ni-Co Specimens are from Vendor No. 1. All Fe-Ni Base Specimens are from Vendor No. 3.
2. Copper under plate peeled.
3. * - Visual inspection
4. BL** - Border Line

TABLE 3. STATISTICAL ANALYSIS DATA COMPARED WITH MIL-STD-883A AND HOT IRON TEST RESULTS (Continued)

	Group 37 Fe-Ni-Co/BAT/Nat. Age							Group 42 Fe-Ni-Co/BAT/Polysulfide						
	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.
Mean	.4155	4.19	697.64	373.4	742.14	Pass	Fail	1.733	3.8	121.	-131.4	24.85	Fail	Fail
Std Dev	.0836	.3136	71.029	49.98	59.065			1.139	.4	202.15	105.30	275.09		
Variance	.00696	.096	4949.9	2486.	3471.15			1.297	.16	40864	11088.5	75675		
#Pts Inc	200	53	53	205	199			91	5	5	179	178		

	Group 38 Fe-Ni-Co/Au/Nat. Age							Group 43 Fe-Ni-Co/Au/Polysulfide						
	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.
Mean	.21	3.262	566.68	349.25	568.51	Pass	Pass	1.0614	3.5	617.0	218.88	507.81	Fail	Fail
Std Dev	.0675	.5839	89.448	71.348	93.159			.7656	1.2747	143.55	278.02	237.79		
Variance	.0033	.3386	7946.15	5065.1	8634.3			.5289	1.3	16486	77294	56548		
#Pts Inc	200	143	145	200	196			184	5	5	172	190		

	Group 39 Fe-Ni/HSD/Nat. Age							Group 44 Fe-Ni/HSD/Polysulfide						
	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.
Mean	.2038	3.5179	653.8	493.5	682.6	Pass	Pass	.8213	3.5857	521.55	72.68	367.95	Fail	Fail
Std Dev	.0554	.5408	63.87	51.196	59.865			.6816	.4285	252.01	200.79	368.51		
Variance	.0031	.2899	4043.5	2607.7	3562.4			.4617	.1784	61694.9	40316	135799.		
#Pts Inc	200	112	112	197	168			160	35	35	199	199		

	Group 40 Fe-Ni/BAT/Nat. Age							Group 45 Fe-Ni/BAT/Polysulfide						
	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.
Mean	.4590	4.0	715.94	371.84	797.10	Pass	Pass	1.9011	-	-	-77.283	192.59	Fail	Fail
Std Dev	.0903	.236	80.398	59.97	51.95			.999	-	-	84.506	229.32		
Variance	.0081	.0526	6059.8	3565.8	2681.0			.9905	-	-	7146.4	52589		
#Pts Inc	200	19	16	120	154			133	-	-	175	188		

Notes:
1. Fe-Ni-Co Base Specimens in Groups 47 through 49 are from Vendor No. 2. All other Fe-Ni-Co Specimens are from Vendor No. 1. All Fe-Ni Base Specimens are from Vendor No. 3.
2. Copper under plate peeled.
3. * - Visual inspection
4. BL** - Border Line

TABLE 3. STATISTICAL ANALYSIS DATA COMPARED WITH MIL-STD-883A AND HOT IRON TEST RESULTS (Continued)

	Group 41 Fe-Ni/Au/Nat. Age						
	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.
Mean	.2068	3.726	605.36	376.52	602.83	Pass	BL**
Std Dev	.1094	.5896	60.53	71.70	68.019		
Variance	.01197	.3476	3663.3	5141.5	4626.6		
#Pts Inc	200	42	42	200	196		

	Group 46 Fe-Ni/Au/Polysulfide						
	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.
Mean	2.1390	-	-	-137.84	151.93	Fail	Fail
Std Dev	1.29	-	-	100.62	261.78		
Variance	1.6519	-	-	10124.9	68529		
#Pts Inc	136	-	-	180	180		

	Group 47 Fe-Ni-Co/BAT/Live Steam						
	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.
Mean	.5613	4.367	776.07	271.3	793.3	Pass	Pass
Std Dev	.0941	.2289	91.75	71.55	63.91		
Variance	.0088	.0489	7857.4	5093.3	4064		
#Pts Inc	199	15	15	200	200		

	Group 48 Fe-Ni-Co/BAT/95/95						
	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.
Mean	.5286	4.1818	765.91	304.3	807.29	Pass	Pass
Std Dev	.2936	.3371	56.75	53.5	36.99		
Variance	.0858	.1033	2927.9	2847.9	1361.8		
#Pts Inc	199	11	11	200	200		

	Group 49 Fe-Ni-Co/BAT/Nat. Age						
	T_1	T_2	T_2DC	1DC	5DC	883A*	H.I.
Mean	.5331	4.1071	724.93	278.29	799.83	Pass	Pass
Std Dev	.0909	.4463	89.65	47.90	44.51		
Variance	.0082	.1849	7501.1	2280.2	1969.2		
#Pts Inc	140	14	15	160	160		

Notes:
1. Fe-Ni-Co Base Specimens in Groups 47 through 49 are from Vendor No. 2. All other Fe-Ni-Co Specimens are from Vendor No. 1. All Fe-Ni Base Specimens are from Vendor No. 3.
2. Copper under plate peeled.
3. * - Visual inspection
4. BL** - Border Line

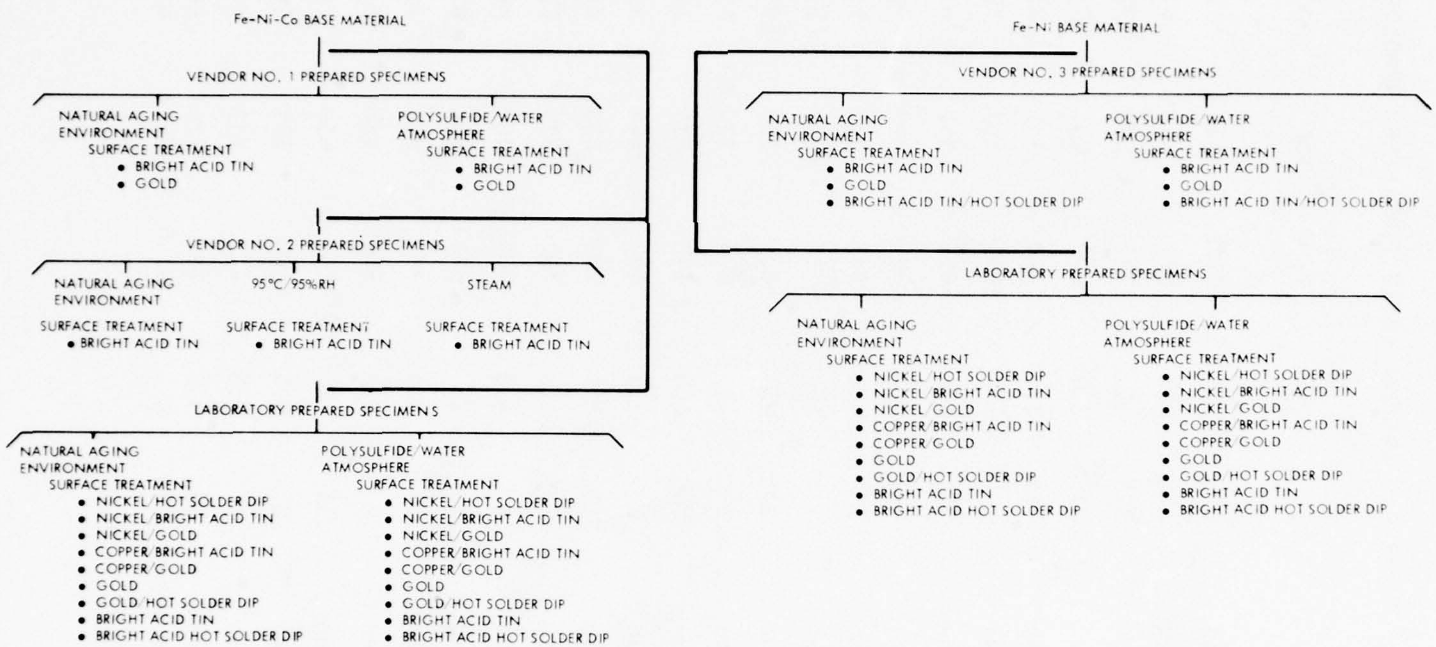

Figure 5. Matrix of Microcircuit Preparation/Aging

TABLE 4. INITIAL (ZERO TIME) TEST RESULTS

Groups		T_1	T_2	T_2DC	1DC	5DC	883A	H.I.
1 and 19	Mean	>5	>5	-216	-216	-216	Fail	Fail
2 and 20	Mean	.15	>5	675	459	675	Pass	Pass
3 and 21	Mean	.275	>5	737	378	737	Pass	Pass
4 and 22	Mean	.275	3.0	600	405	570	Pass	Pass
5 and 23	Mean	.225	3.75	540	351	540	Pass	Pass
6 and 24	Mean	.1	-	595	392	595	Pass	Pass
7 and 25	Mean	.35	4.0	625	351	635	Pass	Pass
8 and 26	Mean	.325	3.5	590	350	600	Pass	Pass
9 and 27	Mean	.3	4.0	652	395	650	Pass	Pass
10 and 28	Mean	>5	>5	-216	-216	-216	Fail	Fail
11 and 29	Mean	.275	>5	>800	500	>800	Pass	Pass
12 and 30	Mean	.2	>5	604	337.5	604	Pass	Pass
13 and 31	Mean	.25	4.0	590	375	590	Pass	Pass
14 and 32	Mean	.2	3.0	600	444	592	Pass	Pass
15 and 33	Mean	.15	>5	697	430	697	Pass	Pass
16 and 34	Mean	.275	4.0	702	399	702	Pass	Pass
17 and 35	Mean	.3	4.0	609	380	609	Pass	Pass
18 and 36	Mean	.4	>5	621	351	621	Pass	Pass
37 and 42	Mean	.4	4.5	759	418	759	Pass	Pass
38 and 43	Mean	.2	4.0	540	324	540	Pass	Pass
39 and 44	Mean	.15	>5	791	459	791	Pass	Pass
40 and 45	Mean	.3	3.5	670	351	662	Pass	Pass
41 and 46	Mean	.1	4.0	673	553	673	Pass	Pass
47 and 48 and 49	Mean	.33	3.5	757	373	>800	Pass	Pass
	Std Dev	.118	0	61.4	88.1	44.1		

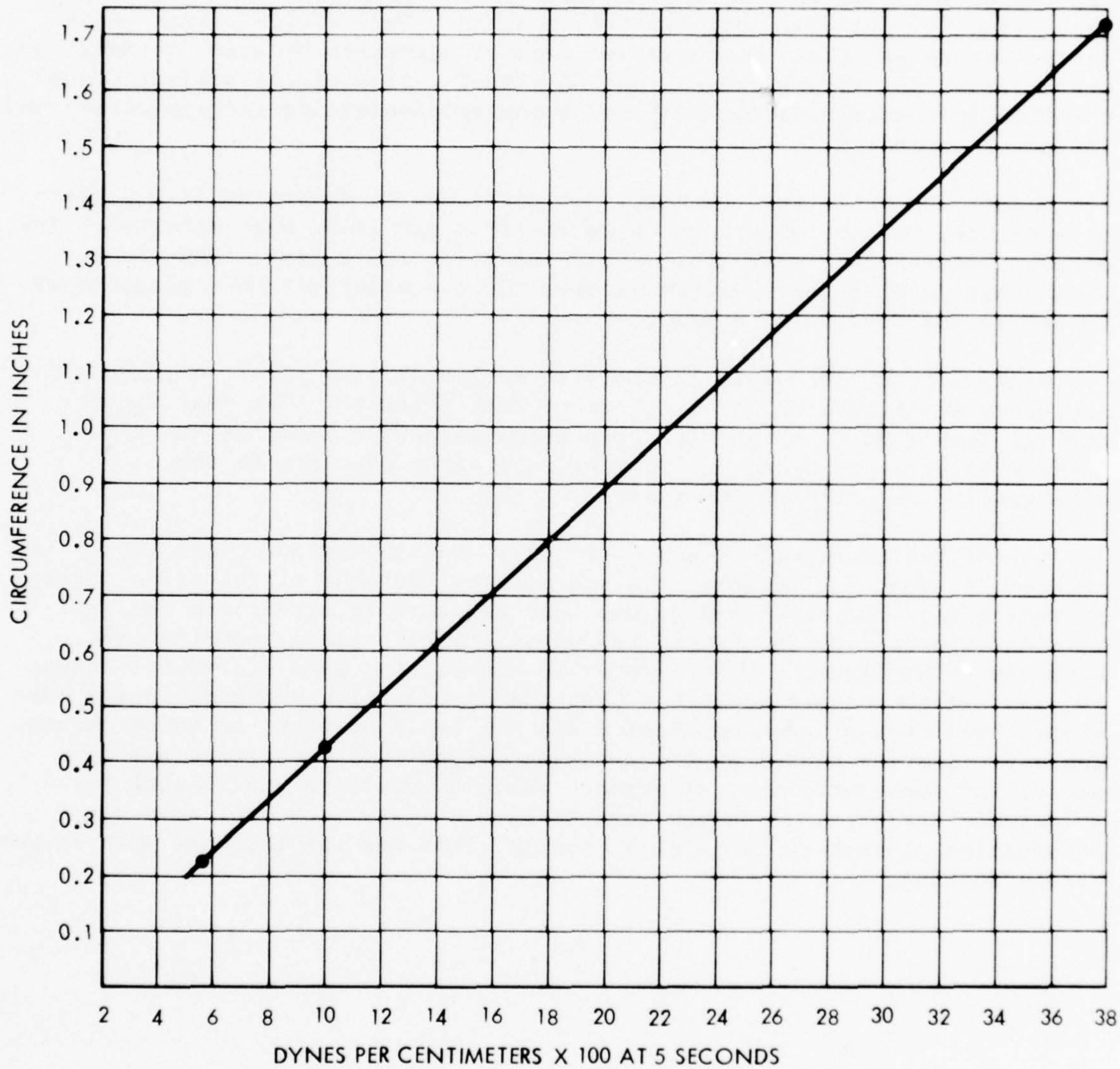

Figure 6. Material Circumference/Dynes per Centimeter

Figure 7 shows the distributions of average T_1 and average 1 DC values from Table 3. These distributions, when compared to the acceptance-rejection criteria of Method 2003.1, result in establishing Meniscograph acceptance-rejection criteria which are compatible. The limits established for acceptance are 0.59 seconds or less to zero balance and 300 dynes per centimeter force or more at the one second test point. These limits apply when using "R" flux for solderability testing. The circled points on the distributions are those which showed lack of agreement between the Meniscograph limits and visual inspection. A visual review of the subject groups resulted in a determination that the acceptance/rejection was subjective and inspector dependent.

A variance ratio test (F test) was performed to determine if a difference existed in test results between Fe-Ni-Co and Fe-Ni base material. The average values of T_1 from Table 3 were used for the F test. The result shows that no difference exists between the two materials when prepared and tested as was done in this study.

Figures 8, 9, 10 and 11 show plots, on probability paper, of cumulative frequency distributions for T_1 (Time to Zero Balance). The four figures compare Vendor No. 2 bright acid tin prepared device leads at -0- time (before exposure to aging environment) and after exposure to three environments as noted on the figures.

The slopes of Figures 8 and 9 are very nearly identical, but T_1 has increased by about 0.2 seconds. This indicates that the distribution characteristics were not disturbed by one hour exposure to steam, and that all devices exposed deteriorated in solderability by a nearly equal amount. When comparing Figure 8 with Figures 10 and 11, the same statements cannot be made. These comparisons show that the distribution characteristics have changed and that all devices tested did not deteriorate by an equal amount. The deterioration caused by the ammonium polysulfide atmosphere was more severe and apparently that atmosphere was a destructive environment for solderable surfaces. Although initial sample tests with a 6% ammonium polysulfide atmosphere had showed promise, this was not the case with larger sample testing.

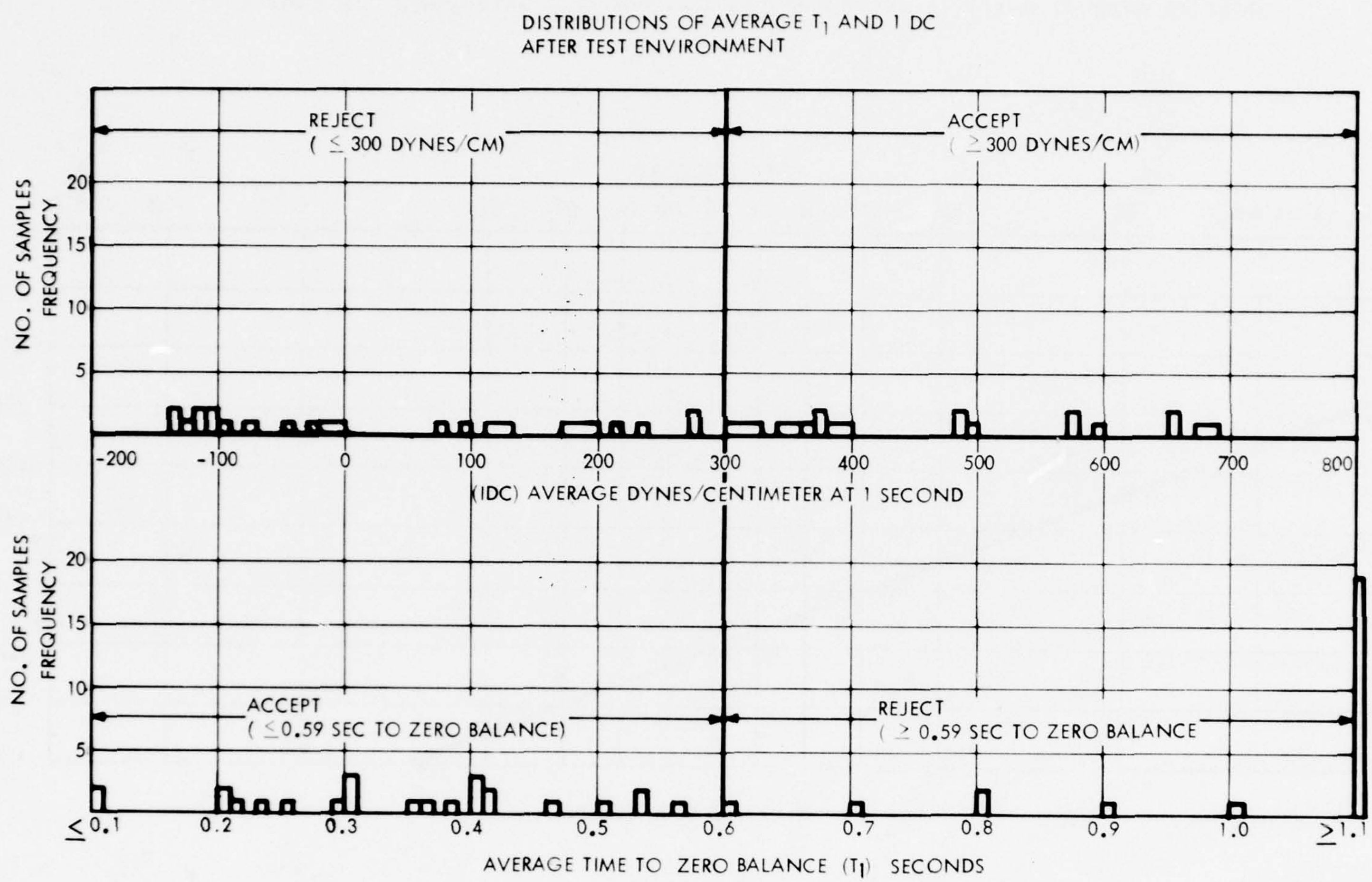

Figure 7. Distribution of Average T_1 and 1 DC After Test Environment

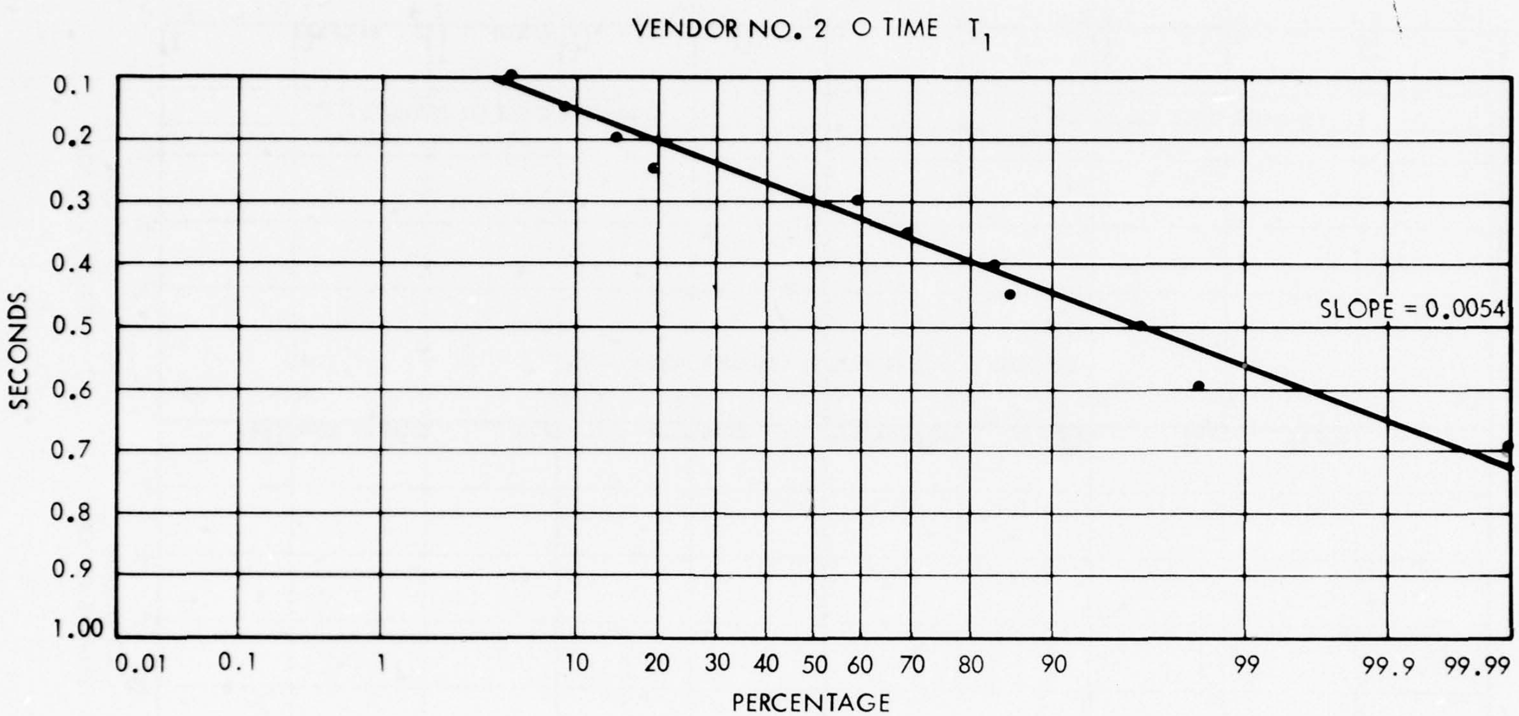

Figure 8. Cumulative Frequency Distribution for T_1 (Time to Zero Balance) for Vendor No. 2 BAT Prepared Device Leads at 0 Time

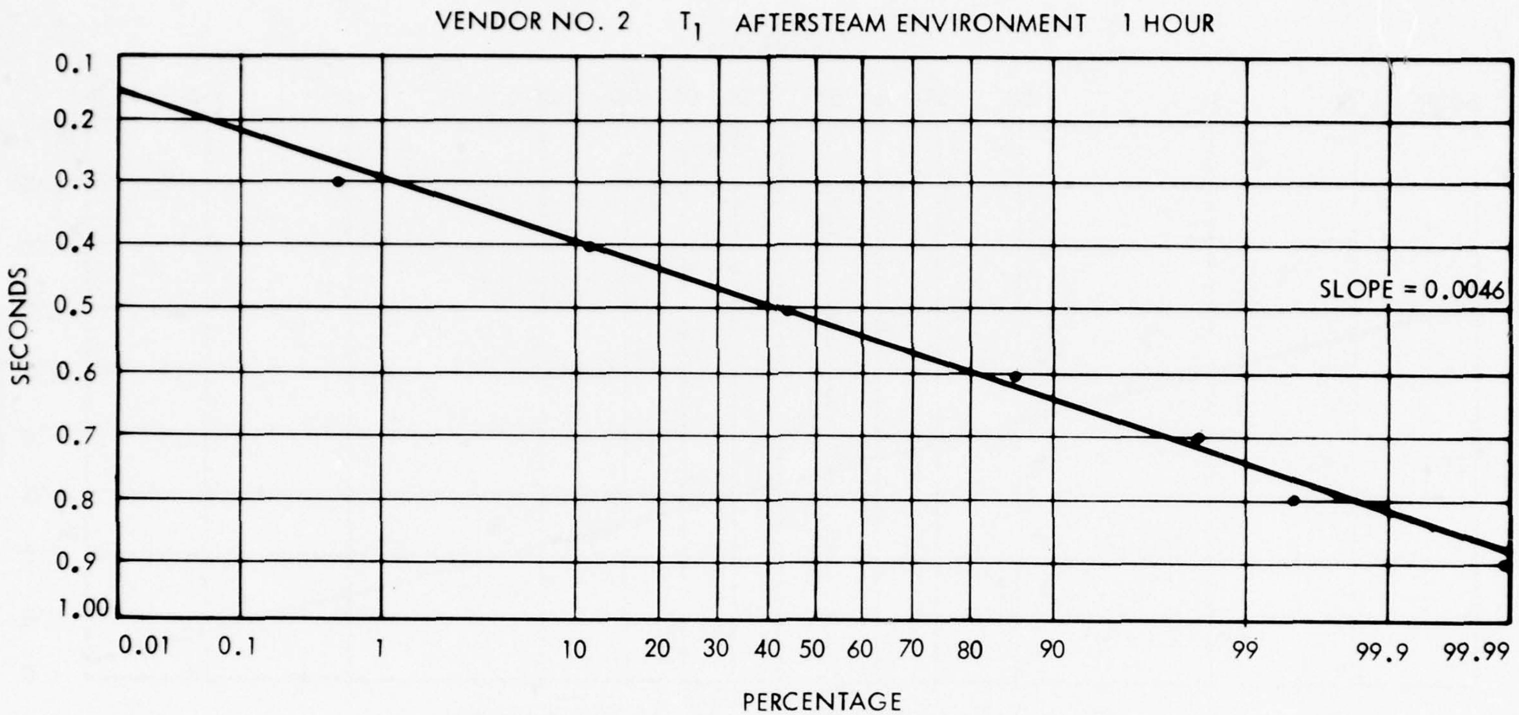

Figure 9. Cumulative Frequency Distribution for T_1 (Time to Zero Balance) for Vendor No. 2 BAT Prepared Device Leads After 1 Hour in Steam Environment

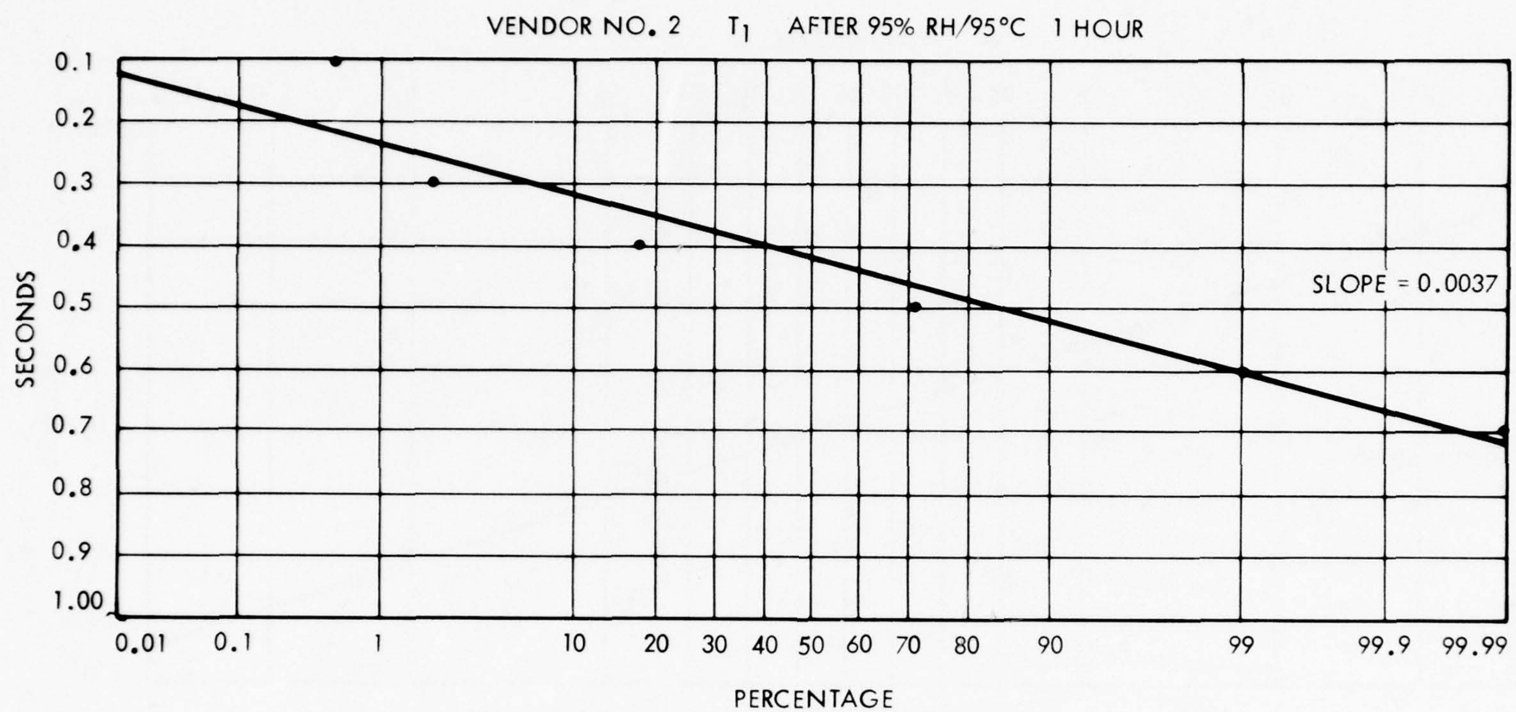

Figure 10. Cumulative Frequency Distribution for T_1 (Time to Zero Balance) for Vendor No. 2 BAT Prepared Device Leads After 1 Hour in 95% RH/95°C

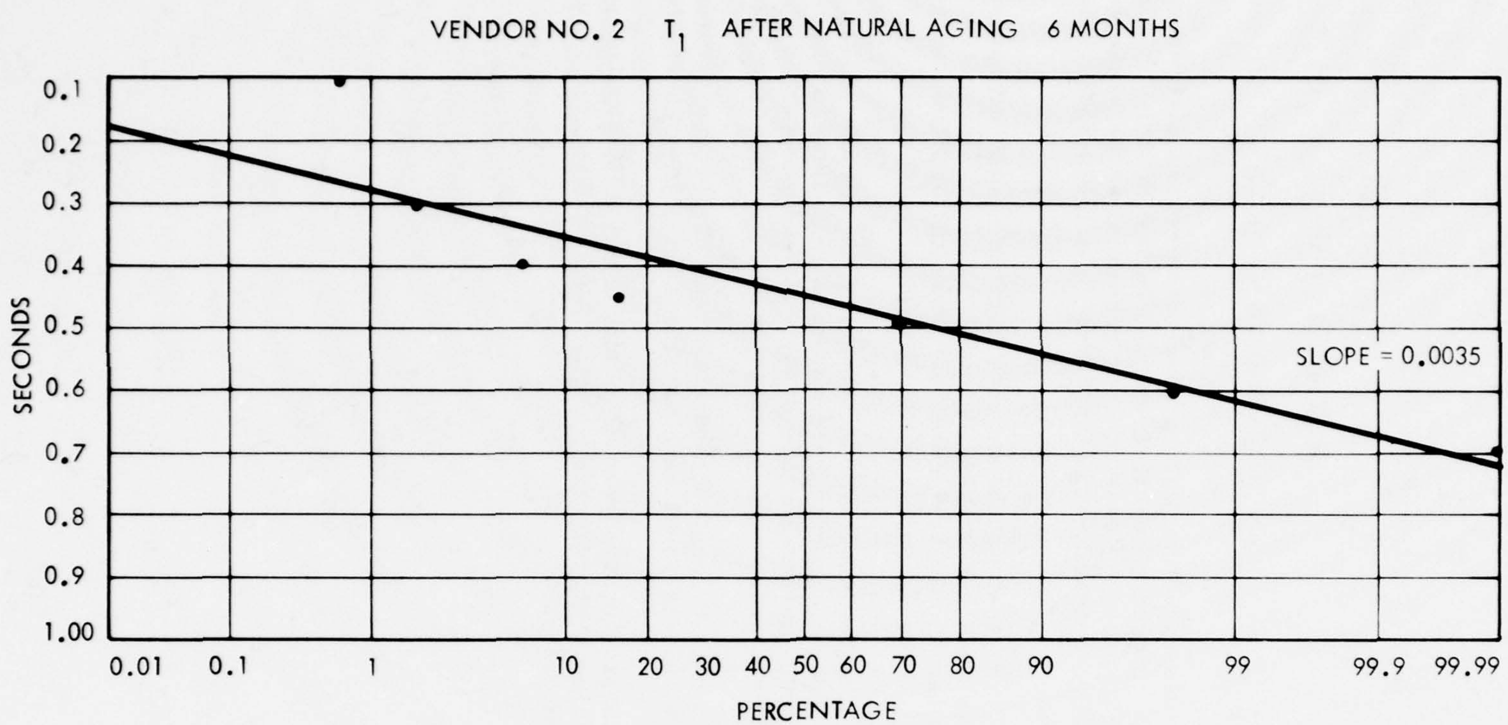

Figure 11. Cumulative Frequency Distribution for T_1 (Time to Zero Balance) for Vendor No. 2 BAT Prpared Device Leads After 6 Months Natural Aging

SECTION 9

CONCLUSIONS

1. The Meniscograph test method results correlate with acceptance criteria currently in MIL-STD-883A, Method 2003.1 for microelectronic package leads. It is recommended that this method, included in Appendix B, be included in MIL-STD-883A, Solderability Testing.

2. The hot iron test method results correlate with acceptance criteria currently in MIL-STD-883A, Method 2003.1 for microelectronic package leads. It is recommended that this method, written in Appendix C, be included in MIL-STD-883A, Solderability Testing.

3. The steam aging environment currently in MIL-STD-883A, Method 2003.1 produces a more uniform device lead deterioration than other environments tested in this study. No evidence was found during this study to recommend a change in the current aging procedure.

4. Comparison test results showed that no difference existed between the Fe-Ni-Co and Fe-Ni base materials used in this study.

5. Study results show that a 6% ammonium polysulfide atmosphere is destructive to solderable surfaces when applied for 20 minutes at room temperature.

SECTION 10

RECOMMENDATIONS

1. An accelerated aging environment should be developed which more nearly equals current microelectronic device handling and storage conditions.

2. MIL-STD-883A acceptance criteria need to be established for other than "R" type flux.

3. The effect of steam aging environment should be further studied on hot solder dip, gold and other types of surface preparation.

4. Consideration should be given to changing the purpose of Method 2003.1 toward the testing of only microcircuits by elimination of lugs, tabs, etc.

NOTE

Method 2003.1 (Appendix A), the Meniscograph Solderability Test Method (Appendix B) and the Hot Iron Solderability Test Method (Appendix C) are intended as fully equivalent test procedures and may be used alternatively in compliance with MIL-STD-883A for solderability testing of microelectronic devices.

APPENDIX A

METHOD 2003.1 SOLDERABILITY

APPENDIX A

METHOD 2003.1* SOLDERABILITY

1. PURPOSE. The purpose of this test method is to determine the solderability of all solid and stranded wires up to 1/8 inch thickness, ribbon leads up to 0.050 inches in width and up to 0.025 inches in thickness, and lugs, tabs, hook leads, turrets, etc., which are normally jointed by a soldering operation. This determination is made on the basis of the ability of these terminations to be wetted or coated by solder, or to form a suitable fillet when dip soldered. These procedures will verify that the treatment used in the manufacturing process to facilitate soldering is satisfactory and that it has been applied to the required portion of the part which is designed to accommodate a solder connection. An accelerated aging test is included in this test method which simulates a minimum of 6 months natural aging under a combination of various storage conditions that have different deleterious effects.

2. APPARATUS.

2.1 Solder pot. A solder pot of sufficient size to contain at least two pounds of solder shall be used. This apparatus shall be capable of maintaining the solder at the temperature specified in 3.4.

2.2 Dipping device. A mechanical dipping device capable of controlling the rates of immersion and emersion of the terminations and providing a dwell time (time of total immersion to the required depth) in the solder bath as specified in 3.4 shall be used.

2.3 Optical equipment. An optical system having a magnification of ten diameters shall be used.

2.4 Container and cover. A nonmetallic container of sufficient size to allow the suspension of the specimens 1-1/2 inches above the boiling distilled water shall be used. (A 2,000 ml beaker is one size that has been used satisfactorily for smaller components.) The cover shall be of one or more stainless steel plates and shall be capable of covering approximately 7/8 of the open area of the container so that a more constant temperature may be obtained. A suitable method of suspending the specimens shall be improvised. Perforations or slots in the plates are permitted for this purpose.

*From MIL-STD-883A dated 15 November 1974.

2.5 Materials.

2.5.1 Flux. The flux shall conform to type RMA or R, as applicable, or MIL-F-14256, "Flux, Soldering, Liquid (Rosin Base)."

2.5.2 Solder. The solder shall conform to type S, composition Sn60, of QQ-S-571, "Solder; Tin Alloy; Lead-Tin Alloy; and Lead Alloy."

3. PROCEDURE. The test procedure shall be performed on the number of terminations specified in the applicable procurement document. During handling, care shall be exercised to prevent the surface to be tested from being abraided or contaminated by grease, perspirants, etc. The test procedure shall consist of the following operations:

(a) Proper preparation of the specimens (see 3.1), if applicable.

(b) Aging of all specimens (see 4.2).

(c) Application of flux and immersion of the terminations into molten solder (see 3.3).

(d) Examination and evaluation of the tested portions of the terminations upon completion of the solder-dip process (see 3.5).

3.1 Preparation of terminations. No wiping, cleaning, scraping, or abrasive cleaning of the terminations shall be performed. Any special preparation of the terminations, such as bending or reorientation prior to the test, shall be specified in the applicable procurement document. If the insulation on stranded wires must be removed, it shall be done in a manner so as not to loosen the strands in the wire.

3.2 Aging. Prior to the application of the flux and subsequent solder dips, all specimens assigned to this test shall be subjected to aging by exposure of the surfaces to be tested to steam in the container specified in 2.4. The specimens shall be suspended so that no portion of the specimen is less than 1-1/2 inches above the boiling distilled water with the cover specified in 2.4 in place for 60 minutes, minimum. Means of suspension shall be a nonmetallic holder. If necessary, additional hot distilled water may be gradually added in small quantities so that the water will continue to boil and the temperature will remain essentially constant.

3.3 Application of flux. Flux, type R, shall be used (see 2.5.1). Terminations shall be immersed in the flux, which is at room ambient temperature, to the minimum depth necessary to cover the surface to be tested. Unless otherwise specified in the applicable procurement document, terminations shall be immersed to within 0.05 inch of the body of the part. The surface to be tested shall be immersed in the flux for a period of from 5 to 10 seconds.

3.4 Solder dip. The dross and burned flux shall be skimmed from the surface of the molten solder specified in 2.5.2. The molten solder shall be maintained at a uniform temperature of 260°C max (500°F). The surface of the molten solder shall be skimmed again just prior to immersing the terminations in the solder. The part shall be attached to a dipping device (see 2.2) and the flux-covered terminations immersed once in the molten solder to the same depth specified in 3.3. The immersion and emersion rates shall be 1 ± 1/4 inch per second and the dwell time in the solder bath shall be 5 ± 1/2 seconds, unless otherwise specified. After the dipping process, the part shall be allowed to cool in air. Residue flux shall be removed from the terminations by sequential rinses in perchlorethylene and isopropyl alcohol. If necessary, a soft damp cloth moistened with clean 91 percent isopropyl alcohol shall be used to remove all remaining flux.

3.5 Examination of terminations. After each dip-coated termination has been thoroughly cleaned of flux, the 1-inch portion of the dipped lead nearest the component, or the whole lead if less than 1 inch, or the fillet area (whichever is applicable), shall be examined using 10 power magnification (see 2.3).

3.5.1 Evaluation of solid wire terminations 0.045 inch or less in diameter, stranded wire No. 18 AWG or smaller and ribbon leads. The criteria for acceptable solderability during the evaluation of the terminations are:

(a) That the termination is at least 95 percent covered by a continuous new solder coating.

(b) That pinholes or voids are not concentrated in one area and do not exceed 5 percent of the total area.

The area of the surface to be tested as specified in 3.5 shall be examined; if any view of the tested surface shows less than 95 percent coverage, the entire lot shall be rejected. In the case of dispute, the percentage of coverage with pinholes or voids shall be determined by the actual measurement of these areas, as compared to the total area.

3.5.2 Evaluation of lugs, tabs, stranded wire greater than No. 18 AWG sizes and solid wire greater than 0.045 inch diameter. The criteria for acceptable solderability during evaluation of the terminations and wires are:

(a) That 95 percent of the total length of fillet, which is between the termination and a connection made to it which typifies the normal connection configuration, be tangent to the surface of the termination being tested and be free from pinholes, voids, etc.

(b) That a ragged or interrupted line at the point of tangency between the fillet and the termination under test shall be considered a defect and included in (a) above.

In case of dispute, the percent of fillet-length with defects shall be determined by actual measurement.

4. SUMMARY. The following details must be specified in the applicable procurement document:

(a) The number of terminations of each part to be tested (see 3).

(b) Special preparation of the terminations, if applicable (see 3.1).

(c) Depth of immersion if other than 0.05 inch (see 3.3).

(d) Solder dip (see 3.4).

(e) Examination of terminations (see 3.5).

(f) Measurements after test, where applicable.

(g) Solder composition, flux, and temperature if other than those specified.

(h) Number of cycles, if other than one. Where more than one cycle is specified to test the resistance of the device to heat as encountered in multiple solderings, the examinations and measurements required shall be made at the end of the first cycle and again at the end of the total number of cycles applied. Failure of the device on any examination and measurement at either the one-cycle or the end point shall constitute failure to meet this requirement.

APPENDIX B

MENISCOGRAPH SOLDERABILITY

APPENDIX B

MENISCOGRAPH SOLDERABILITY

1. PURPOSE. The purpose of this test method is to determine the solderability of all ribbon leads up to 0.050 inches in width and up to 0.025 inches in thickness which are normally joined by a soldering operation and used on microelectronic devices. This determination is made on the basis of the wetting time and wetting force curve produced by the specimen while under test.

These processes will verify that the treatment used in the manufacturing process to facilitate soldering is satisfactory and that it has been applied to the required portion of the part which is designated to accommodate a solder connection.

2. APPARATUS.

2.1 Solder meniscus force measuring device (Meniscograph). A solder meniscus force measuring device (Meniscograph) which includes a temperature-controlled solder pot containing approximately 750 grams of solder shall be used. This apparatus shall be capable of maintaining the solder at the temperature specified in 3.4. The Meniscograph apparatus also includes a strip chart recorder which records the force curve for the device tested.

2.2 Dipping device. A mechanical dipping device is incorporated in the Meniscograph, it is preset to produce an immersion and emersion rate as specified in 3.4. The specimen dwell time is operator controlled to the time specified in 3.4.

2.3 NA for this Test Method.

2.4 Container and cover. A nonmetallic container of sufficient size to allow the suspension of the specimens 1-1/2 inches above the boiling distilled water shall be used. (A 2,000 ml beaker is one size that has been used satisfactorily for smaller components.) The cover shall be of one or more stainless steel plates and shall be capable of covering approximately 7/8 of the open area of the container so that a more constant temperature may be obtained. A suitable method of suspending the specimens shall be improvised. Perforations or slots in the plates are permitted for this purpose.

2.5 Materials.

2.5.1 Flux. The flux shall conform to type RMA or R, as applicable, or MIL-F-14256, "Flux, Soldering, Liquid (Rosin Base)."

2.5.2 Solder. The solder shall conform to type S, composition Sn60, of QQ-S-571, "Solder; Tin Alloy; Lead-Tin Alloy; and Lead Alloy."

3. PROCEDURE. The test procedure shall be performed on the number of terminations specified in the applicable procurement document. During handling, care shall be exercised to prevent the surface to be tested from being abraided or contaminated by grease, perspirants, etc. The test procedure shall consist of the following operations:

(a) Proper preparation of the specimens (see 3.1), if applicable.

(b) Aging of all specimens (see 4.2).

(c) Application of flux and immersion of the terminations into molten solder (see 3.3).

(d) Examination and evaluation of the recordings upon completion of the solder-dip process (see 3.5).

3.1 Preparation of terminations. No wiping, cleaning, scraping, or abrasive cleaning of the terminations shall be performed. Any special preparation of the terminations, such as bending or reorientation prior to the test, shall be specified in the applicable procurement document.

3.2 Aging. Prior to the application of the flux and subsequent solder dips, all specimens assigned to this test shall be subjected to aging by exposure of the surfaces to be tested to steam in the container specified in 2.4. The specimens shall be suspended so that no portion of the specimen is less than 1-1/2 inches above the boiling distilled water with the cover specified in 2.4 in place for 60 minutes, minimum. Means of suspension shall be a nonmetallic holder. If necessary, additional hot distilled water may be gradually added in small quantities so that the water will continue to boil and the temperature will remain essentially constant.

3.3 Application of flux. Flux, type R, shall be used (see 2.5.1). Terminations shall be immersed in the flux, which is at room ambient temperature, to the minimum depth necessary to cover the surface to be tested. Unless otherwise specified in the applicable procurement document, terminations shall be immersed to 4 mm from end of lead. The surface to be tested shall be immersed in the flux for a period of from 5 to 10 seconds.

3.4 Solder dip. The dross and burned flux shall be skimmed from the surface of the molden solder specified in 2.5.2. The molten solder shall be maintained at a uniform temperature of 260°C max (500°F). The surface of the molten solder shall be skimmed again just prior to immersing the terminations in the solder. The part shall be attached to a dipping device (see 2.2) and the flux-covered terminations immersed once in the molten solder to the same depth specified in 3.3. The immersion and emersion rates shall be 1 ±1/4 inch per second and the dwell time in the solder bath shall be 5 ±1/2 seconds, unless otherwise specified.

3.5 <u>Evaluation of resultant Meniscograph curves from testing of microelectronic leads</u>. The criteria for acceptable solderability during the evaluation of the recordings are:

(a) That the recorded signal trace cross the zero balance point at or before 0.59 seconds of test time.

(b) That the recorded signal trace cross the positive 300 dynes per centimeter meniscus force point at or before one second of test time.

3.5.1 NA for this test method.

3.5.2 NA for this test method.

4. <u>SUMMARY</u>. The following details must be specified in the applicable procurement document:

(a) The number of terminations of each part to be tested (see 3.).

(b) Special preparation of the terminations, if applicable (see 3.1).

(c) Depth of immersion if other than 4 mm (see 3.3).

(d) Solder dip (see 3.4).

(e) Evaluation of Meniscograph curves (see 3.5).

(f) Solder composition, flux, and temperature if other than those specified.

(g) Number of cycles, if other than one. Where more than one cycle is specified to test the resistance of the device to heat as encountered in multiple solderings, the examinations and measurements required shall be made at the end of the first cycle and again at the end of the total number of cycles applied. Failure of the device on any examination and measurement at either the one-cycle or the end-point shall constitute failure to meet this requirement.

APPENDIX C

HOT IRON SOLDERABILITY

APPENDIX C

HOT IRON SOLDERABILITY

1. PURPOSE. The purpose of this test method is to determine the solderability of all ribbon leads up to 0.050 inches in width and up to 0.025 inches in thickness which are normally jointed by a soldering operation and used on microelectronic devices. This determination is based on the ability of the solder on the leads to flow and to be moved uniformly. The leads selected for this test must be in a tinned condition and normally require no additional solder.

2. APPARATUS.

2.1 Soldering iron. A temperature controlled soldering iron operating at 650°F with a 1/16 inch diameter tip.

2.2 NA for this test method.

2.3 Optical equipment. A stereo Macroscope capable of 10-15 X.

2.4 NA for this test method.

2.5 Materials.

2.5.1 Flux. The flux shall conform to type RMA or R, as applicable, or MIL-F-14256, "Flux, Soldering, Liquid (Rosin Base)."

2.5.2 Solder. The solder shall conform to type S, composition Sn60, of QQ-S-571, "Solder; Tin Alloy; Lead-Tin Alloy; and Lead Alloy.

3. PROCEDURE. The test procedure shall be performed on the number of terminations specified in the applicable procurement document. During handling, care shall be exercised to prevent the surface to be tested from being abraided or contaminated by grease, perspirants, etc. The test procedure shall consist of the following operations:

(a) Proper preparation of the specimens (see 3.1), if applicable.

(b) Application of flux (see 3.3).

(c) Examination and evaluation of the tested portions of the terminations upon completion of the hot iron process (see 3.5).

3.1 Preparation of terminations. No wiping, cleaning, scraping, or abrasive cleaning of the terminations shall be performed. Any special preparation of the terminations, such as bending or reorientation prior to the test, shall be specified in the applicable procurement document. The leads shall be in a tinned condition prior to test.

3.2 NA for this test method.

3.3 Application of flux. Flux, type R, shall be used (see 2.5.1). Terminations shall be immersed in the flux, which is at room ambient temperature, to the minimum depth necessary to cover the surface to be tested. Unless otherwise specified in the applicable procurement, document, terminations shall be immersed to within 0.05 inch of the body of the part. The surface to be tested shall be immersed in the flux for a period of from 5 to 10 seconds.

3.4 Hot iron application.

3.4.1 The dross and burned flux shall be wiped from the surface of the soldering iron specified in 2.1. The soldering iron shall be maintained at a uniform temperature of 650°F.

3.4.2 The soldering iron tip shall be well tinned and totally free from residual burned flux and dross.

3.4.3 Holding the previously fluxed leads in view under the microscope, apply the heated soldering iron to the tip of the lead while observing the solder as it becomes liquid. While the solder is still molten on the lead move the iron along one edge of the lead toward the flatpack body. Then bring the iron tip onto the lead surface in view and slowly draw it through the solder and off the lead tip.

3.5 Hot iron solderability evaluation.

3.5.1 Non-wetting or de-wetting, if present, usually appear rapidly upon heating.

3.5.2 The molten solder should not appear lumpy or produce spikes at the point of removal of the iron tip.

3.5.3 When the iron is moved across the lead surface, a permanent parting of the solder should not occur. This is an indication of de-wetting.

3.5.4 Finally, all de-wetting, non-wetting, slushy, lumpy, sluggish solder formation indicates poor solderability and lead failure.

NOTE: No estimate or percent coverage is used in this test. The device being examined must be solder tinned prior to testing.

4. SUMMARY. The following details must be specified in the applicable procurement document:

(a) The number of terminations of each part to be tested (see 3.).

(b) Special preparation of the terminations, if applicable (see 3.1).

(c) Depth of immersion if other than 0.05 inch (see 3.3).

(d) Hot iron application (3.4).

(e) Examination of terminations (see 3.5).

(f) Solder composition, flux, and temperature if other than those specified.

(g) Number of cycles; one cycle per lead.

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METRIC SYSTEM

BASE UNITS:

Quantity	Unit	SI Symbol	Formula
length	metre	m	...
mass	kilogram	kg	...
time	second	s	...
electric current	ampere	A	...
thermodynamic temperature	kelvin	K	...
amount of substance	mole	mol	...
luminous intensity	candela	cd	...
SUPPLEMENTARY UNITS:			
plane angle	radian	rad	...
solid angle	steradian	sr	...

DERIVED UNITS:

Quantity	Unit	SI Symbol	Formula
Acceleration	metre per second squared	...	m/s
activity (of a radioactive source)	disintegration per second	...	(disintegration)/s
angular acceleration	radian per second squared	...	rad/s
angular velocity	radian per second	...	rad/s
area	square metre	...	m
density	kilogram per cubic metre	...	kg/m
electric capacitance	farad	F	A·s/V
electrical conductance	siemens	S	A/V
electric field strength	volt per metre	...	V/m
electric inductance	henry	H	V·s/A
electric potential difference	volt	V	W/A
electric resistance	ohm		V/A
electromotive force	volt	V	W/A
energy	joule	J	N·m
entropy	joule per kelvin	...	J/K
force	newton	N	kg·m/s
frequency	hertz	Hz	(cycle)/s
illuminance	lux	lx	lm/m
luminance	candela per square metre	...	cd/m
luminous flux	lumen	lm	cd·sr
magnetic field strength	ampere per metre	...	A/m
magnetic flux	weber	Wb	V·s
magnetic flux density	tesla	T	Wb/m
magnetomotive force	ampere	A	...
power	watt	W	J/s
pressure	pascal	Pa	N/m
quantity of electricity	coulomb	C	A·s
quantity of heat	joule	J	N·m
radiant intensity	watt per steradian	...	W/sr
specific heat	joule per kilogram-kelvin	...	J/kg·K
stress	pascal	Pa	N/m
thermal conductivity	watt per metre-kelvin	...	W/m·K
velocity	metre per second	...	m/s
viscosity, dynamic	pascal-second	...	Pa·s
viscosity, kinematic	square metre per second	...	m/s
voltage	volt	V	W/A
volume	cubic metre	...	m
wavenumber	reciprocal metre	...	(wave)/m
work	joule	J	N·m

SI PREFIXES:

Multiplication Factors	Prefix	SI Symbol
1 000 000 000 000 = 10^{12}	tera	T
1 000 000 000 = 10^{9}	giga	G
1 000 000 = 10^{6}	mega	M
1 000 = 10^{3}	kilo	k
100 = 10^{2}	hecto*	h
10 = 10^{1}	deka*	da
0.1 = 10^{-1}	deci*	d
0.01 = 10^{-2}	centi*	c
0.001 = 10^{-3}	milli	m
0.000 001 = 10^{-6}	micro	μ
0.000 000 001 = 10^{-9}	nano	n
0.000 000 000 001 = 10^{-12}	pico	p
0.000 000 000 000 001 = 10^{-15}	femto	f
0.000 000 000 000 000 001 = 10^{-18}	atto	a

* To be avoided where possible.

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